Dens screw fixation: Is it all it’s cut out to be?

RPB von Bormann MBChB (UCT)
Registrar: Division of Orthopaedic Surgery, University of Cape Town

K Steyn MBChB (Stell)
Registrar: Division of Orthopaedic Surgery, University of Stellenbosch on ASCI Unit rotation

RN Dunn MBChB (UCT), MMed(Orth), FCS(SA)Orth
Head of Spinal Services, Division of Orthopaedic Surgery, University of Cape Town

Reprint requests:
Dr RN Dunn
robdunn@mweb.co.za
Fax: 0866 715 294
Telephone: (021) 404-5108

Abstract
Anterior dens screw fixation is a well-documented treatment option for type II dens fractures. The advantage of this procedure is believed to be the preservation of rotation at C1-2 (50% of C-spine rotation occurs at C1-2).

Aim:
This study aimed to assess the results of anterior peg screw fixation in our hands.

Methods:
A retrospective review was done of 22 consecutive patients managed with anterior peg screw fixation over a five-year period. Each patient’s clinical notes, radiological studies, operative findings and procedure and their final functional outcomes were reviewed. Average follow-up was 7.3 months.

Results:
The average displacement at the fracture site was 3.42 mm, with 10 going posteriorly, seven anteriorly and five undisplaced. The average operative time was 95.35 minutes, with an average blood loss of 127 ml (10-800 ml). There were six intra-operative complications relating either to technical difficulties or imaging problems. One screw was discovered only postoperatively to be placed posterior to the peg. Another screw cut out and necessitated surgical revision. Two patients suffered from significant dysphagia postoperatively. Eighteen (82%) of the patients had evidence of radiographic union.
Average cervical rotation, given as a percentage of the normal 90° of rotation was 46.9% to the right and 45% to the left.

Conclusion:
Anterior peg screw fixation is a technically challenging procedure with a relatively high complication rate that does not predictably preserve atlanto-axial rotation.
Introduction

Dens fractures are common, making up approximately 20% of cervical spine fractures, where cervical spine injuries make up 60% of all spinal injuries. Using the Anderson and D’Alonzo classification, the type I (cephalad tip fractures) and type III (extending into the vertebral body) fractures provide few difficulties in terms of management decisions. Conservative management yields 100% bony union in type I fractures and over 84% in type III. Type II fractures make up 65-75% of dens fractures and it is these injuries that present the most difficulties in terms of management decisions. Factors associated with a high rate of non-union comprise initial displacement of more than 5 mm, posterior displacement, comminution, age greater than 60 years, and insufficient immobilisation. A non-union of the dens can result in secondary spinal cord injury or progressive myelopathy from C1-2.

Multiple treatment options are available for the management of type II Dens fractures. Conservative options include the Minerva POP jacket, cervical-spine collars, and the halo-jacket. Traditionally surgical fusion techniques were performed posteriorly, such as wiring techniques (Gallie, Brooks and Jenkins technique), C1-2 trans-articular screws fixation and more recently C1 lateral mass screws / C2 isthmic screws. Anteriorly, the odontoid peg screw has been utilised for the direct fixation of the fracture after accurate reduction. This has the stated benefit of preserving C1-2 motion, principally rotation, thus theoretically making it superior to posterior forms of fusion.

In this study we have reviewed the results of anterior odontoid screw fixation technique and looked in particular at whether or not rotation is preserved.

Method and materials

A database of all spinal surgery performed within the Groote Schuur Hospital Spinal Unit is maintained prospectively. This was interrogated for all odontoid fracture cases managed by anterior odontoid screw fixation. Twenty-two consecutively managed patients were identified within the five-year period October 2001 to March 2006. Case notes and radiology were assessed retrospectively in terms of epidemiology and surgical complications. Functional outcome in terms of cervical range of motion was recorded on clinical follow-up.

The surgical technique was performed by three different consultants over this period. After general anaesthesia, the patient was positioned supine with the neck extended. The fracture was generally reduced pre-operatively in traction but on occasion required gentle manipulation of the head/neck during positioning to optimise the position. The Dens-axis set (Synthes) was utilised. The spine was accessed by a right-sided Smith-Robinson approach and the guide wire was placed with the help of simultaneous biplanar imaging, one anterior posterior and the other lateral. A cannulated technique was utilised, and after drilling an appropriate length screw was inserted.
The average operating time (incision to closure) was 95.4 minutes (35-150 min). Blood loss averaged 127 ml ± 222.731 ml (10-800 ml). This reduces to 60 ml if the outlier (800 ml) is removed. The 800 ml case was one of the non-contiguous associated spinal fractures, where the C7/T1 bifacet dislocation required anterior discectomy and reduction through the same approach as the dens screw. There was profuse epidural bleeding associated with the sub-axial part of the procedure.

**Dens fractures are common, making up approximately 20% of cervical spine fractures**

Postoperatively, reduction and adequate fixation was assessed by open mouth and lateral X-rays. The patient was immobilised in a Philadelphia collar for eight weeks, but allowed to ambulate, and discharged home when comfortable. Mobilisation of the cervical spine was encouraged after eight weeks but formal physiotherapy was often not available due to state resource limitation.

**Results**

**Demographics**
The demographic of our patient group was in keeping with other large series in the literature, being predominantly young males. There were 17 (77%) males and five (23%) females. The average age was 37 ± 16.9 (19-75) years.

**Injury pattern**
Of the 22 patients, two were type III fractures. They had minimal body involvement and were expected to behave like a type II. In addition, they were polytrauma cases not suitable for conservative management. The rest were type II fractures (Figure 2).

Posterop displacement was evident in 10 (45%) of the pegs (Figure 3), seven (32%) had displaced anteriorly and five remained undisplaced. The average displacement was 3.21 ± 3.0 (0-11) mm.

**Mode of injury**
Sixteen patients were involved in motor vehicle accidents, comprising five occupants and 11 pedestrians. Four patients sustained their fractures in falls from a height, although one of these was thrown from a moving train. Two patients sustained injuries as the result of blunt assault.

**Associated injuries**
Nine of the 22 patients sustained polytrauma with multiple associated injuries. Five patients had only isolated appendicular skeleton fractures.

Four of the patients in this series suffered non-contiguous simultaneous spinal column injuries. These included a T5 fracture, a T3-4 dislocation, a C7-T1 bifacet dislocation, and a C5-6 unfacet dislocation (Figure 5). Five patients had sustained spinal cord injuries although two of these were at the level of the non-contiguous spinal column injury below the C2 fracture. Three of the spinal column injuries were motor-and-sensory-complete (MSC), and the other two were motor-and-sensory-incomplete (MSI). Of the C2 spinal cord injuries, two were scored as C4 MSI and one C4 MSC, using the American Spinal Injury Association (ASIA) classification, where the deficit is termed by the last normal level.
Technical challenges encountered

Inherent in this procedure is the difficulty of attempting to achieve a three-dimensional reduction and fixation of the odontoid peg fracture using a two-dimensional image. Two image intensifiers are necessary to achieve the two-dimensional image with the ability to simultaneously visualise both the anterior-posterior and lateral images. The use of two machines requires significant theatre space and can make physical access to the patient awkward for the surgical team. The other technical difficulty encountered is the hindrance to the correct trajectory for guide wire and screw placement, which the anterior chest wall can provide.

Complications

Intra-operative complications:
- Two guide wires cut out
- One screw stripped
- One guide wire jammed and reduction was lost

Unrecognised misplacement:
- Two screws were placed eccentric in the peg (Figure 6)
- One screw was placed eccentric to the peg

Postoperative complications:
- Two patients experienced transient dysphagia
- Two screws backed out, thus losing fixation (Figure 7)
- One screw cut out of the body of C2 anteriorly (Figure 8)
In a single patient the guide wire cut out intra-operatively and needed to be re-sited. On formal postoperative imaging it was realised that the screw was in fact placed outside the peg. The patient was taken back to theatre and underwent revision of the anterior peg screw. This screw backed out in the first postoperative week. Again the patient returned to the operating table and then underwent posterior fusion with two C1-2 trans-articular screws. The patient then went on to uneventful union of C1-2.

Follow-up
Average follow up was 7.3 months ± 6.79 (3-29). Eighteen (82%) of the patients went on to radiological union (Figure 9). Of these, two went on to form anterior bony bridges between C1 and C2 (Figure 10).

Range of motion
The ranges of motion for the cervical spine are assessed using a chin vertex line for flexion-extension, and a sagittal midline for lateral bending and rotation. The guideline values for normal range of motion are 80º of flexion, 50º of extension, 45º of lateral bending, and 80º-88º to the left and right for rotation. Motion at the C1-2 interface allows negligible flexion-extension and lateral bending, but approximately 40-44º (50%) of cervical rotation.
One of the main aforementioned goals of this study was the assessment of the preservation of rotation at C1-2 which the peg screw is understood to offer. Functional cervical rotation, taken as the patient’s full active rotation of the head to each side, was assessed. This was a clinical assessment of each patient carried out at their final outpatient visit. The average total cervical rotation to the right was 41.3° ± 23.6° (10°-90°) which represents 46.9% of expected normal range, and to the left of 40° ± 24.8° (10°-88°) representing 45% of expected normal range.

Discussion
The base of skull, atlas and axis form a single integrated functional unit whose unconstrained joints are dependent on ligamentous check reins for stability. It is this that allows the upper cervical spine to contribute roughly 50% of each of the cervical spine motions. Dvorak using CT scan assessment of cadavers showed that approximately 50% of rotation occurs at C1-2. This amounts to 40-44° to the left and to the right, with the axis rotating on the odontoid peg of the atlas. The total rotation achieved by the C-spine is 80-88° to each side.

It is the C1-2 that surgeons attempt to preserve with the use of anterior screw fixation of the dens. The technique precludes the need for an upper cervical fusion thus theoretically allowing C1 to continue to rotate on C2.

In this study patients lost 45% of expected total cervical rotation. This is in keeping with the 50% loss of total cervical rotation which fusion at C1-2 produces. These findings suggest that some combination of the bony callus and soft tissue scarring, which results from both the initial and surgical trauma, results in a complete or partial fusion of C1-2 preventing or restricting motion at this level.

The standard orthopaedic textbook, Rockwood & Green’s *Fractures in Adults* describes restoration of some rotatory motion by use of the peg screw and ascribe the demonstration of this to Bohler et al. and Aebi et al. Critical assessment of Bohler et al’s results shows very limited rotatory advantage. The twelve patients who received combined anterior and posterior stabilisation and fusion of C1-2 had a resultant average range of rotation of approximately 49° to each side. The eleven patients who were treated with anterior dens screw fixation for acute fractures achieved an approximate average of 56.8° rotation to each side. Thus the use of the anterior screw has resulted in a preservation of rotation of 7.8° to each side. Aebi et al give no figures for normal, or pre- and post-op range of motion, stating only that post-op range of motion was “minimally decreased”, and ‘relative to their subjective previous abilities’.

There is a dearth of articles quantifying significant preservation of rotation. Morandi et al in 1999 present ‘good’ functional results for rotation, but do not quantify this, saying only “good” when describing “stability-mobility”. Harrop et al and Bhanot et al describe the anterior dens screw as preserving normal rotation, but give no figures. Shilpaker et al do the same, listing only the results of others such as Aebi and Bohler, while Borne describes only functional results in terms of; “no postoperative aggravation”. Lee et al in 2004, described anterior screw fixation as superior to posterior arthrodesis as it preserves rotational movement. This article does not however give any results for motion and also simply refers to Bohler’s results. In 1999 Henry & Bohly’s combined published results produced a large series of 61 patients treated by anterior screw fixation. This series showed a full range of cervical movement in 43 of 61 patients with limitation of less than 25% in 12 patients, and greater than 25% in six. Unfortunately definitive ranges are not stated leaving this a largely subjective assessment.

Some authors describe ‘good’ results with the odontoid screw but show rotation results comparable to those demonstrated in this series. Fountas et al present a series of 50 patients and describe achieving a satisfactory range of motion with an average rotation of the cervical spine to the right of 23.9° and to the left of 39°. This represents a greater than 60% loss of rotation. A functional computed tomography examination of atlanto-axial rotation post dens screw fixation was performed on 13 patients by Jeanneret et al in 1991. This demonstrated an average atlanto-axial rotation of 24.6° to each side at C1-2, compared to a norm of 40-44°. It thus appears that despite an overall perception of preserved atlanto-axial rotation, it is not substantiated in the numerous studies claiming good outcomes.

The other consideration when assessing the value of a surgical procedure is the complication rate, which appears high with this technique. In our series of 22 patients, there were six complications (27%). The relatively high complication rate associated with this procedure is documented in other published series and reviews in the literature. Aebi et al noted a 24% complication rate, and Lee et al 10%. Ettar et al reported a 17% major complication rate and 13% minor. In Henry and Bohly’s series of 61 patients they had one death, three early mechanical failures of internal fixation, and 16 “general complications”. A literature review of 19 series (252 cases), done by Subach et al demonstrates an overall complication rate of 9.5%, the most common complications being screw malposition and screw pullout.

Subach’s review also showed that fusion rates with anterior dens screw fixation are reliably good with an average 96% fusion and this is supported by most other studies. This is borne out to some extent in our series although a longer follow-up may have increased our fusion rates.
Conclusion
Anterior screw fixation of odontoid peg fractures has been shown to achieve similar fusion rates to posterior fixation options. It is however a technically challenging procedure with consistently higher complication rates.

The stated advantage of this procedure is the preservation of atlanto-axial rotation. Our study brings this into question, as cervical rotation was not predictably preserved. Furthermore, a review of the literature fails to offer support for this assertion.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. This research was submitted to the following ethical committee and passed: Departmental Research Committee, University of Cape Town

References